Name: _____

Chemistry 129.01   Spring 2017

General Chemistry

Midterm Examination:

    Equations, constants and periodic table are provided.

    You may use a calculator.

    Show all your work!

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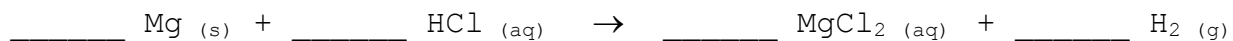
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Bonus: _____/2

Total: _____/150

1. (20 pts.) A 1.32 g sample of impure magnesium was analyzed by allowing to react with an excess of HCl solution:

a) Balance the chemical equation for this reaction. (2 pts.)

_____ Mg $_{(s)}$ + _____ HCl $_{(aq)}$ → _____ MgCl$_2$ $_{(aq)}$ + _____ H$_2$ $_{(g)}$

b) Determine the oxidation number of each element (in each reactant and product). Which element is reduced and which oxidized? Which are the oxidizing agent and reducing agent? (8 pts.)

Reactants		Products	
Element	Oxidation	Element	Oxidation Number
Mg		Mg	
H		H	
Cl		Cl	

c) After the impure metal was treated with 100.0mL of 0.750 M HCl, 0.0125 mol HCl remained. Assuming the impurities do not react with the acid, was is the %Mg in the sample? (8 pts.)

d) Assuming the volume of the solution remains constant, what is the concentration of MgCl$_2$ produced? (2 pts.)

2. (18 pts.) Consider the following molecules: **XeF$_2$, NO$_2$, TeF$_5^-$.** (i) Draw their Lewis structure, (ii) Determine the electron group and molecular geometries, (iii) Is the molecule polar or nonpolar? (iv) Hybridization of central atom

(a)   XeF$_2$

Electron Group Geometry: _____

Molecular Geometry: _____

Polar or Nonpolar?: _____

Hybridization of Central Atom: _____

(b)   NO$_2$

Electron Group Geometry: _____

Molecular Geometry: _____

Polar or Nonpolar?: _____

Hybridization of Central Atom: _____

(c)   TeF$_5^-$

Electron Group Geometry: _____

Molecular Geometry: _____

Polar or Nonpolar?: _____

Hybridization of Central Atom: _____

3. (i) (3 pts) Draw the following orbitals (shape and orientation):
dx^2-y^2 , p_y and dz^2 orbitals

(ii)(2 pts) Tell whether the following combinations of quantum numbers
are allowed or not allowed.

$n = 2$, $l = 3$, $m_l = -1$ _____

$n = 3$, $l = 2$, $m_l = +2$ _____

(iii) (4 pts) What is the maximum number of electrons that can have of
the following quantum numbers?

$n = 4$, $l = 3$, $m_s = -\frac{1}{2}$ _____

$n = 3$, $l = 2$ _____

4. (6 pts.) Fill in the gaps in the following table.

Name	Formula
silver dichromate	
	$CrCl_3$
	$Fe(ClO_4)_2$
dinitrogen tetroxide	
	SO_2
sodium phosphate	

5. (2 pts) (i) Write the **full** electron configuration for **Mn.**

(ii) (3pts) Arrange the following elements in order of **increasing** atomic radius: Mg, F, Rb$^+$, Al, Rb, S

(iii) (3 pts) Arrange the following elements in order of **increasing** ionization energy: O, Cs, B, Ga, Sr.

(iv) (5 pts) Arrange the following atoms in order of **increasing** electronegativity: H, Cs, N.

What type of bond (ionic, polar or nonpolar) would each of those atoms make with another N atom?

    H   _____

    Cs   _____

    N   _____

6. (7 pts)   The energy of an orbit in the hydrogen atom is:

$$E_n = -2.18 \times 10^{-18} J \left(\frac{1}{n^2} \right) \qquad where\ n = 1, 2, 3...$$

(a)   For an electron transition in the hydrogen atom from n=4 to n=1, what is the associated change in energy? Does this transition correspond to absorption or emission of energy? (4 pts.)

(b)   What is the wavelength of light this energy change corresponds to? What type of electromagnetic radiation is this? (3 pts.)
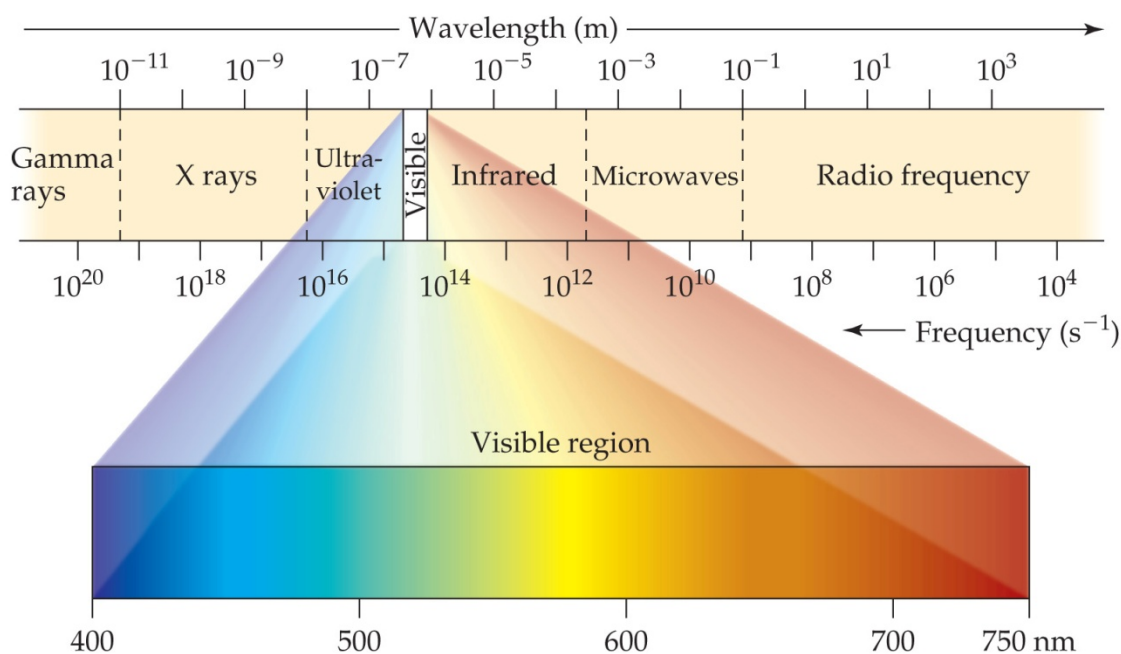
7. (17 pts.) Consider the F_2 molecule:

   a. (8 pts) Draw the <u>molecular orbital energy-level diagram</u> for F_2 and write its electron configuration. Label all the atomic orbitals and molecular orbitals. Sketch the shape of a π_{2p} and a $\pi_{2p}*$ molecular orbitals.

   b. (3 pts) Determine the bond order of F_2. Is F_2 paramagnetic or diamagnetic?   Why?

   c. (6 pts.) If two electrons are removed from F_2 to form F_2^{2+}, how many unpaired electrons would F_2^{2+} have? Calculate the bond order of F_2^{2+}. Which would you expect to have a stronger bond, F_2 or F_2^{2+}? Longer bond? Why?

8. (10 pts) Menthol (molar mass = 156 g/mol) is a compound of C, H, and O. When 0.1005g of menthol was subjected to combustion analysis, it produced 0.2829g CO_2 and 0.1159g H_2O. Find the empirical and molecular formulas of menthol.

9. (11 pts.) (a) What are the hybridizations of the **four carbon,** the **two oxygen,** and **two nitrogen** atoms?
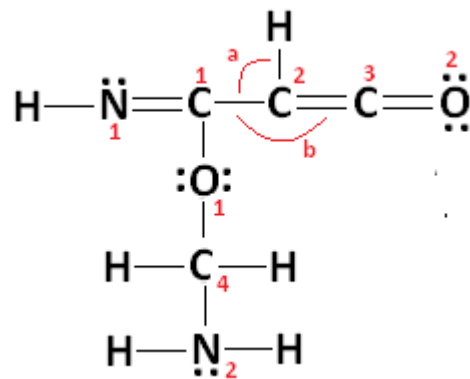
C$_1$: _____   O$_1$: _____   N$_1$: _____

C$_2$: _____   O$_2$: _____   N$_2$: _____

C$_3$: _____

C$_4$: _____

How many sigma bonds and pi bonds does the molecule have?

_____ sigma bonds   _____ pi bonds


(c) Which angle is smaller a or b? Explain.

10. (15pts) (a) When KCl dissolves in water, the main force of attraction that exists between Cl^- and H_2O is called _____.

    (b)   Chlorine (Cl_2) is a gas at room temperature. What is the major attractive force that exists among different Cl_2 molecules in the gas? _____.

    (c)   Arrange the following in order of **increasing** boiling point: CH_3CH_2OH, $CH_3CH_2CH_3$, and CH_3OCH_3. Explain.

    (d)   Which molecule would you expect to be <u>more</u> soluble in water, CCl_4 or $CHCl_3$? Why?

11. (15pts) (i) The phase diagram of a hypothetical substance is shown
in the following figure. Identify the phase(s) present at points A
through F.
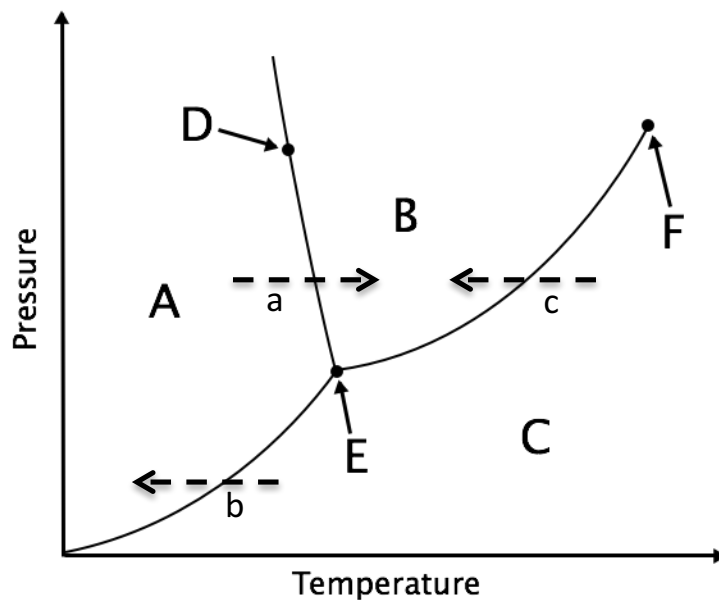
A: _____

B: _____

C: _____

D: _____

E: _____

F: _____ (beyond this point)

(ii) Name the phase change shown by the underlined dashed arrows. Is the
process endothermic or exothermic?

a. _____

b. _____

c. _____

12. (i) (6 pts) Draw the **atomic orbital diagram** of **oxygen** and show
the number of valence electrons, core electrons and unpaired
electrons.

(ii) (3 pts.) The oxide ion, O^{2-}, is isoelectronic (has exactly the
same number and configuration of electrons) with Ne, and yet O^{2-} is
bigger than Ne. Why?

Bonus: (2 pts)

Arrange the following in order of increasing length. Explain.

Cl—Cl   H—H   H—Cl